

What is claimed is:

1. A system for autonomously keeping an aircraft's station in a formation flight of a plurality of aircraft, the system comprising:

a navigation system configured to determine a position of an aircraft;  
5           a data link configured to allow the aircraft to communicate data with at least one other aircraft in a formation flight of a plurality of aircraft;  
a sensor configured to sense position of other aircraft within a predetermined distance of the aircraft; and  
10           a processor configured to provide control signals to keep the aircraft at a predetermined station relative to the other of the plurality of aircraft in the formation flight.

2. The system of Claim 1, wherein the navigation system includes an embedded GPS inertial navigation system.

3. The system of Claim 2, wherein position uncertainty of the navigation system is 15 within around 30 meters.

4. The system of Claim 2, wherein position uncertainty of the navigation system is within around 1 meter.

5. The system of Claim 4, wherein the navigation system is configured to process PY GPS signals.

- 20       6. The system of Claim 1, wherein the data link includes Link 16.

7. The system of Claim 1, wherein the data link includes an ARC 210 data link.

8. The system of Claim 1, wherein the data link includes a millimeter wave radar.

9. The system of Claim 1, wherein the data communicated includes a flight plan of the aircraft.

- 25       10. The system of Claim 1, wherein the sensor includes a millimeter wave radar.

11. The system of Claim 10, wherein the predetermined distance is around 10 miles.



25315

PATENT TRADEMARK OFFICE



12. The system of Claim 1, wherein the predetermined station is within around 1,000 feet of other aircraft in the formation.

13. The system of Claim 1, wherein the processor includes a first component configured to generate first control signals for performing a collision avoidance maneuver when the position of the aircraft is within a first predetermined threshold from the other aircraft in the formation.  
5

14. The system of Claim 13, wherein the collision avoidance maneuver includes at least one of changing altitude of the aircraft in an opposite direction from changing altitude of the other aircraft and turning away from the other aircraft.

10 15. The system of Claim 13, wherein the first predetermined threshold includes a time period in a range of around 1 second to around 2 seconds before a collision becomes unavoidable.

16. The system of Claim 13, wherein the first predetermined threshold includes a distance of around 150 feet.

15 17. The system of Claim 13, wherein the processor includes a second component configured to generate second control signals for performing a collision deconfliction maneuver when the position of the aircraft is within a second predetermined threshold from the other aircraft in the formation, the second predetermined threshold being greater than the first predetermined threshold.

20 18. The system of Claim 17, wherein the collision deconfliction maneuver includes at least one of changing altitude of the aircraft in an opposite direction from changing altitude of the other aircraft and turning away from the other aircraft and changing speed of the aircraft opposite changing speed of the other aircraft .

25 19. The system of Claim 16, wherein the second predetermined threshold includes a time period of around 30 seconds before a collision becomes unavoidable.

20. A system for autonomously keeping an aircraft's station in a formation flight of a plurality of aircraft, the system comprising:  
an embedded GPS inertial navigation system configured to determine a position of an aircraft;



25315

PATENT TRADEMARK OFFICE



a data link configured to allow the aircraft to communicate data with at least one other aircraft in a formation flight of a plurality of aircraft;

a millimeter wave radar system configured to sense position of other aircraft within a predetermined distance of the aircraft; and

5 a processor configured to provide control signals to keep the aircraft at a predetermined station relative to the other of the plurality of aircraft in the formation flight, the processor including:

10       a first component configured to generate first control signals for performing a collision avoidance maneuver when the position of the aircraft is within a first predetermined threshold from the other aircraft in the formation; and

15       a second component configured to generate second control signals for performing a collision deconfliction maneuver when the position of the aircraft is within a second predetermined threshold from the other aircraft in the formation, the second predetermined threshold being greater than the first predetermined threshold.

21. The system of Claim 20, wherein position uncertainty of the navigation system is within around 30 meters.

22. The system of Claim 20, wherein position uncertainty of the navigation system is 20 within around 1 meter.

23. The system of Claim 20, wherein the navigation system is configured to process PY GPS signals.

24. The system of Claim 20, wherein the data link includes Link 16.

25. The system of Claim 20, wherein the data link includes an ARC 210 data link.

26. The system of Claim 20, wherein the data link includes a millimeter wave radar.

27. The system of Claim 20, wherein the data communicated includes a flight plan of the aircraft.



25315

PATENT TRADEMARK OFFICE



28. The system of Claim 20, wherein the predetermined station is within around 1,000 feet of other aircraft in the formation.

29. The system of Claim 20, wherein the predetermined distance is around 10 miles.

30. The system of Claim 20, wherein the collision avoidance maneuver includes at least 5 one of changing altitude of the aircraft in an opposite direction from changing altitude of the other aircraft and turning away from the other aircraft.

31. The system of Claim 20, wherein the first predetermined threshold includes a time period in a range of around 1 second to around 2 seconds before a collision becomes unavoidable.

10 32. The system of Claim 20, wherein the first predetermined threshold includes a distance of around 150 feet.

33. The system of Claim 20, wherein the collision deconfliction maneuver includes at least one of changing altitude of the aircraft in an opposite direction from changing altitude of the other aircraft and turning away from the other aircraft and changing speed of the 15 aircraft opposite changing speed of the other aircraft.

34. The system of Claim 20, wherein the second predetermined threshold includes a time period of around 30 seconds before a collision becomes unavoidable.

35. A method of automatically keeping a predetermined station of an aircraft flying in a formation flight of a plurality of aircraft, the method comprising:

20 transmitting a flight plan of an aircraft flying in a formation flight of a plurality of aircraft, the aircraft having a predetermined station in the formation flight relative to other aircraft in the formation flight;  
determining position of the aircraft;  
sensing position of other aircraft in the formation;  
25 comparing position of the aircraft with position of other aircraft in the formation;  
and  
automatically adjusting position of the aircraft relative to positions of the other aircraft flying in the formation flight such that the predetermined station of the aircraft is maintained.



25315

PATENT TRADEMARK OFFICE



36. The method of Claim 35, wherein automatically adjusting the position includes adjusting at least one of course and speed and altitude of the aircraft.

37. The method of Claim 35, wherein the predetermined station is at least around 1,000 feet from other aircraft in the formation.

5 38. The method of Claim 35, wherein position of the aircraft is determined within a position uncertainty of around 30 meters.

39. The method of Claim 35, wherein position of the aircraft is determined within a position uncertainty of around 1 meter.

10 40. The method of Claim 35, wherein the other aircraft are sensed at distances of at least around 10 miles from the aircraft.

41. The method of Claim 35, further comprising performing a collision avoidance maneuver when the position of the aircraft is within a first predetermined threshold from the other aircraft in the formation.

15 42. The method of Claim 41, wherein performing the collision avoidance maneuver includes at least one of changing altitude of the aircraft in an opposite direction from changing altitude of the other aircraft and turning away from the other aircraft..

43. The system of Claim 41, wherein the first predetermined threshold includes a time period in a range of around 1 second to around 2 seconds before a collision becomes unavoidable.

20 44. The method of Claim 41, wherein the first predetermined threshold includes a distance of around 150 feet.

45. The method of Claim 41, further comprising performing a collision deconfliction maneuver when the position of the aircraft is within a second predetermined threshold from the other aircraft in the formation, the second predetermined threshold being greater than the first predetermined threshold.

25 46. The method of Claim 45, wherein performing the collision deconfliction maneuver includes at least one of changing altitude of the aircraft in an opposite direction from changing altitude of the other aircraft and turning away from the other aircraft and changing speed of the aircraft opposite changing speed of the other aircraft.



47. The method of Claim 45, wherein the second predetermined threshold includes a time period of around 30 seconds before a collision becomes unavoidable.

48. An aircraft comprising:

- 5      a fuselage;
- 10     a pair of wings;
- a plurality of flight control surfaces;
- at least one engine;
- an autoflight system; and
- a system for autonomously keeping the aircraft's station in a formation flight of a plurality of aircraft, the system including:
  - a navigation system configured to determine a position of an aircraft;
  - a data link configured to allow the aircraft to communicate data with at least one other aircraft in a formation flight of a plurality of aircraft;
  - a sensor configured to sense position of other aircraft within a predetermined distance of the aircraft; and
  - a processor configured to provide control signals to the autoflight system to keep the aircraft at a predetermined station relative to the other of the plurality of aircraft in the formation flight.

49. The aircraft of Claim 48, wherein the navigation system includes an embedded GPS inertial navigation system.

50. The aircraft of Claim 49, wherein position uncertainty of the navigation system is within around 30 meters.

51. The aircraft of Claim 49, wherein position uncertainty of the navigation system is within around 1 meter.

25     52. The aircraft of Claim 51, wherein the navigation system is configured to process PY GPS signals.

53. The aircraft of Claim 48, wherein the data link includes Link 16.

54. The aircraft of Claim 48, wherein the data link includes an ARC 210 data link.



55. The aircraft of Claim 48, wherein the data link includes a millimeter wave radar.
56. The aircraft of Claim 48, wherein the data communicated includes a flight plan of the aircraft.
57. The aircraft of Claim 48, wherein the sensor includes a millimeter wave radar.
58. The aircraft of Claim 57, wherein the predetermined distance is around 10 miles.
59. The aircraft of Claim 48, wherein the predetermined station is within around 1,000 feet of other aircraft in the formation.
60. The aircraft of Claim 48, wherein the processor includes a first component configured to generate first control signals for performing a collision avoidance maneuver when the position of the aircraft is within a first predetermined threshold from the other aircraft in the formation.
- 10 61. The aircraft of Claim 60, wherein the collision avoidance maneuver includes at least one of changing altitude of the aircraft in an opposite direction from changing altitude of the other aircraft and turning away from the other aircraft.
- 15 62. The system of Claim 60, wherein the first predetermined threshold includes a time period in a range of around 1 second to around 2 seconds before a collision becomes unavoidable.
63. The aircraft of Claim 60, wherein the first predetermined threshold includes a distance of around 150 feet.
- 20 64. The aircraft of Claim 60, wherein the processor includes a second component configured to generate second control signals for performing a collision deconfliction maneuver when the position of the aircraft is within a second predetermined threshold from the other aircraft in the formation, the second predetermined threshold being greater than the first predetermined threshold.
- 25 65. The aircraft of Claim 64, wherein the collision deconfliction maneuver includes at least one of changing altitude of the aircraft in an opposite direction from changing altitude of the other aircraft and turning away from the other aircraft and changing speed of the aircraft opposite changing speed of the other aircraft.



25315

PATENT TRADEMARK OFFICE

66. The aircraft of Claim 64, wherein the second predetermined threshold includes a time period of around 30 seconds before a collision becomes unavoidable.



25315

PATENT TRADEMARK OFFICE

- 22 -

BOEI-1-1204AP

BLACK LOWE & GRAHAM PLLC

  
816 Second Avenue  
Seattle, Washington 98104  
206.381.3300 • F: 206.381.3301